# SOUND LOCALIZATION UNDER DETERMINED EXPECTATION[1]

By L. R. Geissler

It had frequently been observed by the writer that under ordinary circumstances his sound-localization seemed to be strongly influenced by a determined expectation or direction of attention. The only direct reference to this problem in the experimental literature known to the author is that made by Pierce,[2] in connection with experiments in which "the method of procedure was to move the sound until the subject was aware of the direction in which movement was taking place." In discussing the results, Pierce says: "from among the various directions theoretically possible from a physical point of view, certain circumstances will usually determine which direction shall be actually perceived. The expectation of the subject is often the deciding factor. This expectation may be the result of a recent localization which makes one direction of the attention easier than another, or it may be due to some suggestion inadvertently given. And when once a given direction of movement has been perceived, false though it may be, localizations of adjacent positions will the more readily fall in line with the direction first perceived. This determining influence of both suggestion and of an antecedent localization will appear still more clearly on later pages." Our present experiments were planned for the special purpose of determining quantitatively to what extent the expectation of a stationary sound from a certain direction influenced the localization of this sound.

The writer was greatly aided in the conduct of these experiments by Mrs. Ruth Collins Desch, who had previously in co-operation with C. E. Ferree investigated another phase of the problem of auditory localization.[3] Our experiments began Jan. 24th and lasted to April 25th, 1914. They were performed on twenty observers, each of whom made 68 individual localizations which could be finished in a single session of not more than about 90 minutes. Twelve observers were men students of the senior class who had completed a full year's introductory course (based on Titchener's "Textbook"), and about four months or more of qualitative laboratory work (based on Titchener's Qualitative Students' Manual), which had included in every case the experiment on touch-localization (No. 33) as a sort of special preliminary training. The eight women observers ranked from the junior class of a girls' preparatory school to teachers of several years' experience in that school; none of them had had special

[1] From the Psychological Laboratory of the University of Georgia, Athens, Ga. Read in parts before the Am. Psych. Association, Dec. 31, 1914, Philadelphia, Pa.

[2] A. H. Pierce, Studies in Auditory and Visual Space Perception, 1901, 57.

[3] C. E. Ferree and Ruth Collins, An Experimental Demonstration of the Binaural Ratio as a Factor in Auditory Localization, Am. J. Ps., April 1911, xxii, 250-297.

psychological preparation. The writer gladly takes this opportunity to express his hearty thanks to Mrs. Desch for many helpful suggestions in performing the experiments and in preparing this article, as well as to Misses M. E. Jeffcott, Dorothy Selby, Sara Lamar, Helen Michael, Janet Newton, Pauline Odum, Julia Orr, Ruth Reid, and to Messrs. G. Barrett, A. B. Bernd, T. N. Hendricks, W. E. Hitchcock, F. Holden, T. A. Maxwell, J. E. McDonald, L. Michael, J. Myers, H. M. Pitts, E. R. Pund, and H. D. Williams, for their patient and conscientious work as observers and their deep interest in the problem.

The sound-cage was built in the middle of a symmetrically constructed room of 3.1 x 6.2 meters, which contained only one table and two chairs, so that possible echoes from the faint stimulus were neutralized or, more probably, eliminated. The observer's head, facing the windows, was in the center of a noiselessly rotating wooden lever-system which carried two little telephone receivers at exactly opposite positions, about 75 cm. from the center of the head, and at the level of the ears when the observer sat on a chair placed in the center of the apparatus. The sound-stimulus was produced by noiselessly and quickly closing and opening a double-throw baby-knife switch in circuit with the receiver and two dry cells. The observers were blindfolded, care being taken that the bandage did not touch the pinna. The position of the stimulus was determined by means of a protractor-scale in the center of the lever-system above the observer's head. The zero-point was at the back, 180 in front, the positions on the right were called *plus,* those on the left *minus,* so that the aural axis passed through $\pm$ 90°. While the sound could be given at any point on the circumference of the horizontal plane passing through the ears, the observers were instructed that it would be given only at 10° intervals; actually it was given only at intervals of 30°, namely 0, $\pm$ 30, $\pm$ 60, $\pm$ 90, $\pm$ 120, $\pm$ 150, and 180. The observers were given a sufficient number of preliminary trials to memorize this schema. The localizations were made in two ways, by pointing with finger and by visual-verbal reference to the scale, unless the latter method was preferred exclusively. The bandaged eyes prevented the use of the cardboard chart employed by some investigators. Whenever an observer used both methods, care was taken that pointing and verbal reference to scale did not conflict.

In our method the greatest importance must be laid on the instructions given to the observers and the subsequent reports demanded from them. After having been told that the general purpose of the investigation was to find out how well they could localize a faint sound under certain circumstances, they were instructed sometimes to direct their best attention to one part of the circle only, to think of it and nothing else, and to expect the sound to come from that particular direction. If sometimes the sound seemed to come from a place entirely different from the one indicated, that fact should not in any way disturb their future observations, as such differences were naturally to be expected. Again, they were told that sometimes they were not to limit their attention and expectation, not to expect the sound from any definite point; this instruction was briefly expressed by the command "Unlimited." Then, as soon as the sound was heard, its position was to be indicated immediately, and in addition the observers were asked to tell from what point they had expected the sound, either definitely or in general, that is, whether from points or from areas or regions on the scale. They were urged to be perfectly frank to tell whether they had disobeyed the instruction or not, as that mistake was less serious than deception. Aside from the

behavior toward the instruction "Unlimited," which will be dealt with in detail under the rubric of results, several observers reported failures to follow the instruction for special direction of expectation in certain cases, in which the experiments were repeated at a later time. Both reports of localization and expectation were recorded, and the writer is confident that instructions were conscientiously carried out by all observers. In addition to these reports, ten of our men observers were also asked at the end of their respective sessions to give an introspective account of the usual course of consciousness during an observation, beginning with the instruction and stopping with the beginning of the report.

The 68 observations made by each subject were divided into two groups, the first containing 5 series of ten tests each. A short pause was made after each of these series and a longer one after the whole group. The 18 observations of the second group were taken without any interruptions. In the first group, before each observation, the subject was instructed whether to limit his expectation of the sound to one of the halves, by the words "right half," "left half," "front half," or "back half," or whether not to expect the sound from anywhere in particular, by the word "unlimited." A second after this instruction the warning signal "ready" was given, and after about two more seconds the sound-stimulus was presented. The positions 0 and 180 were never used with the instruction "right" or "left;" likewise ± 90 were omitted as stimuli when expectation was to be limited to the front or back half. Each of the 12 stimulus-positions was presented once with the instruction "unlimited." With limited expectation the stimulus was presented once at each position in the *required* half and once at each position in the *opposite* half. The intermediate positions ± 30, ± 60, ± 120, and ± 150 had thus to occur four times each, while the corner positions ± 90, 0, and 180 occurred only twice each, in addition to the single occurrence with "unlimited" as instruction. Each series of ten observations included two "unlimited" cases and two cases for each half, in such a way that the stimulus was actually given in the *same* half as often as in the *opposite* half. In the second group of experiments the expectation was limited to the quadrants by the instructions "right front," "left front," "right back," and "left back." Only the intermediate positions were used as stimuli, except in one "unlimited" case and in another case where the sound was presented in some "different" position; otherwise these experiments were carried on like those of the first group. The following schema represents the actual order of instructions and corresponding stimulus-positions which each of the twenty observers completed.

SCHEMA OF ORDER OF PROCEDURE

| Instr. | Stim. Pos. | Ser. 1 | Ser. 2 | Ser. 3 | Ser. 4 | Ser. 5 | Instr. | Stim. Pos. | Quadrants | |
|---|---|---|---|---|---|---|---|---|---|---|
| Unlim't'd | anywhere | +120 | +90 | +30 | +150 | +60 | Rt. Fr. | same Qu. | +150 | +120 |
| Fr. half | same half | —120 | 180 | —150 | +120 | +150 | L. B'k. | diff. " | +30 | +150 |
| Rt. " | opp. " | —90 | —150 | —120 | —30 | —60 | L. Fr. | same " | —120 | —150 |
| L. " | same " | —30 | —60 | —90 | —120 | —150 | Rt. B'k. | diff. " | 180 | —120 |
| B'k. " | opp. " | 180 | +150 | +120 | —150 | —120 | Unlim. | anywh. | —60 | 0 |
| Rt. " | same " | +150 | +120 | +90 | +60 | +30 | L. B'k. | same Qu. | —30 | —60 |
| Unlim't'd | anywhere | —150 | —120 | —30 | 180 | —90 | Rt. Fr. | diff " | —150 | —30 |
| Fr. half | opp. half | +30 | +60 | 0 | —60 | —30 | Rt. B'k. | same " | +60 | +30 |
| B'k. " | same " | —60 | —30 | +60 | +30 | 0 | L. Fr. | diff. " | +120 | +60 |
| L. " | opp. " | +60 | +30 | +150 | +90 | +120 | | | | |

A brief examination of this schema will show that the same combination of instruction and stimulus-position was never given more than once in each series.

In computing and tabulating our results we fractionated the data both as to stimulus-position and as to instruction concerning the direction of expectation, and averaged either localizations of all twenty observers or of one group of observations as compared with another group. The percentages of error in localization for any given direction of expectation with all possible stimulus-positions were calculated by adding the errors, that is, the differences between the stimulus-positions and the corresponding averages, and dividing this sum by the sum of all employed stimulus-positions. Conversely, the magnitude of error, or amount of displacement, for any given stimulus-position under all kinds of expectation employed was determined by adding the corresponding averages, dividing the sum by the number of cases involved, and subtracting the result from the stimulus-position. In the Tables which follow the decimal fractions have been omitted, although at least one decimal position was always used in the calculations. Among the various abbreviations used in the Tables, No. refers always to the number of cases from which the average or error is calculated. MV. stands for mean-variation, E. means error, and Tot. or T. stands for total; other abbreviations will be self-evident or explained in the subsequent discussion of the Table in which they are used.

Before attempting to determine whether direction of expectation has any influence upon sound-localization, it is necessary to study our data from a general standpoint and as far as possible to compare them with results obtained by previous workers in this field. For this purpose we must refer the reader to rubric h of Table I and to the first 28 rows of Table II. These results show clearly the general tendency of sound-displacement that other authors have found, namely that sounds from behind the ears are frequently referred forward and those from in front are referred backward, that is, are referred toward the aural axis or in some cases even beyond it. In our results the greatest displacement occurs with the stimulus at 0, the sixty localizations averaging 129.2; but if we subtract from these the twenty localizations under instructed forward direction of expectation, the remaining forty observations average still as high as 123.2. The actual places at which stimulus 0 was localized are shown in rows 1 and 2 of Table II. In row 2, for example, that is with "unlimited" and "back half" direction of expectation, the sound coming from 0 was localized 9 times at 0, twice at 10, once at 120, 3 times at 150, and so forth. Likewise all the other even-numbered rows contain the reduced observations, that is, those localizations in which the direction of expectation was to the same half in which the sound would be given. With the exception of stimulus-positions $\pm$ 90 the "reduced" observations show a smaller displacement error than the total, thus indicating in general the unfavorable influence of direction of expectation upon the accuracy of sound-localization. With the stimulus at 180 our results show a good deal less backward displacement than other investigators seem to have observed, the error being only 10.5 for the reduced number of observations. The smallest errors occur with stimuli 90, which show a slight backward displacement of about 5°. The second largest error is found with 30, a displacement of 75.2° and 67.5° for the right and left side respectively, while all other stimuli show an error varying between 19.0° and 25.0°, either forward or backward.

TABLE I

| Rows | Rubrics | a | | | b | | | c | | | d | | | e | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unlimited or No Expectation | | | | | | | | | Expectation Limited to Right or Left | | | | | |
| | Instr. Stimulus Position | Gen. Results | | | No Exp'n. | | | Vol. Lim. Exp'n. | | | St. in Opp. H. | | | St. in Same H. | | |
| | | Av. | Mv. | E. | No. | Av. | Mv. | No. | Av. | Mv. | Av. | Mv. | E. | Av. | Mv. | E. |
| 1 | 0 | 135 | 54 | 135 | 3 | 120 | 40 | 17 | 138 | 49 | .. | .. | .. | .. | .. | .. |
| 2 | +30 | 120 | 23 | 90 | 7 | 121 | 30 | 13 | 119 | 20 | 109 | 37 | 79 | 119 | 26 | 89 |
| 3 | —30 | 116 | 53 | 86 | 5 | 66 | 47 | 15 | 133 | 32 | 104 | 38 | 74 | 102 | 54 | 72 |
| 4 | +60 | 87 | 15 | 27 | 6 | 108 | 18 | 14 | 81 | 14 | 84 | 14 | 24 | 92 | 8 | 32 |
| 5 | —60 | 91 | 16 | 31 | 7 | 86 | 13 | 13 | 98 | 11 | 88 | 14 | 28 | 85 | 20 | 25 |
| 6 | Tot. Bck. | 110 | .. | 74 | 28 | 100 | .. | 72 | 114 | .. | 94 | .. | 51 | 100 | .. | 55 |
| 7 | +90 | 86 | 12 | 4 | 6 | 95 | 13 | 14 | 83 | 10 | 91 | 5 | 1 | 82 | 8 | 8 |
| 8 | —90 | 90 | 13 | 0 | 5 | 84 | 9 | 15 | 93 | 15 | 88 | 12 | 2 | 89 | 12 | 1 |
| 9 | +120 | 91 | 12 | 29 | 9 | 93 | 9 | 11 | 90 | 14 | 95 | 15 | 25 | 95 | 22 | 25 |
| 10 | —120 | 107 | 15 | 13 | 8 | 109 | 21 | 12 | 106 | 12 | 99 | 10 | 21 | 91 | 8 | 21 |
| 11 | +150 | 130 | 16 | 20 | 5 | 126 | 19 | 15 | 131 | 20 | 137 | 25 | 13 | 115 | 23 | 35 |
| 12 | —150 | 139 | 13 | 11 | 8 | 120 | 24 | 12 | 152 | 19 | 142 | 12 | 8 | 125 | 23 | 25 |
| 13 | 180 | 151 | 29 | 29 | 6 | 142 | 57 | 14 | 155 | 39 | .. | .. | .. | .. | .. | .. |
| 14 | Tot. Fr. | 124 | .. | 20 | 36 | 119 | .. | 64 | 127 | .. | 118 | .. | 17 | 107 | .. | 28 |
| 15 | No. Expt. | 240 | | | 75 | | | 165 | | | 200 | | | 200 | | |
| 16 | $\frac{\Sigma \text{Errors}}{\Sigma \text{St. Pos.}}$ | $\frac{475}{1080}=44.0\%$ | | | $\frac{462}{1080}=42.8\%$ | | | $\frac{487}{1080}=45.2\%$ | | | $\frac{275}{900}=30.0\%$ | | | $\frac{331}{900}=36.8\%$ | | |
| 17 | Eliminating 0, ±90, and 180 | $\frac{307}{720}=42.6\%$ | | | $\frac{293}{720}=40.7\%$ | | | $\frac{316}{720}=44.0\%$ | | | $\frac{272}{720}=37.8\%$ | | | $\frac{323}{720}=44.9\%$ | | |

TABLE I—*Continued*

| Rows | Rubrics | f | | | g | | | h | | | i | | | j | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Instr. Stimulus Position | Expectation Lim. to Front or Back | | | | | | Total Results Rubrics a and d–g | | | Expectation Lim. to Quadrants | | | | | |
| | | In opp. half | | | In same half | | | | | | St. in diff. | | | In same Qu. | | |
| | | Av. | Mv. | E. | Av. | Mv. | E. | No. | Av. | E. | Av. | Mv. | E. | Av. | Mv. | E. |
| 1 | 0 | 141 | 56 | 141 | 110 | 75 | 110 | 60 | 129 | 129 | .. | .. | .. | .. | .. | .. |
| 2 | +30 | 126 | 88 | 96 | 76 | 44 | 46 | 100 | 109 | 79 | 110 | 44 | 80 | 85 | 33 | 55 |
| 3 | —30 | 117 | 46 | 87 | 74 | 53 | 44 | 100 | 103 | 73 | 126 | 32 | 96 | 85 | 45 | 55 |
| 4 | +60 | 99 | 13 | 39 | 74 | 12 | 44 | 100 | 87 | 27 | 98 | 15 | 38 | 66 | 14 | 6 |
| 5 | —60 | 93 | 11 | 33 | 76 | 18 | 16 | 100 | 87 | 27 | Not given | | | 72 | 14 | 12 |
| 6 | Tot. Back | 115 | .. | 79 | 82 | .. | 46 | 460 | 103 | 67 | 111 | .. | 71 | 77 | .. | 32 |
| 7 | +90 | .. | .. | .. | .. | .. | .. | 60 | 86 | 4 | .. | .. | .. | .. | .. | .. |
| 8 | —90 | .. | .. | .. | .. | .. | .. | 60 | 86 | 4 | .. | .. | .. | .. | .. | .. |
| 9 | +120 | 82 | 22 | 38 | 104 | 10 | 16 | 100 | 94 | 26 | 103 | 11 | 17 | 102 | 11 | 18 |
| 10 | —120 | 87 | 11 | 33 | 99 | 10 | 21 | 100 | 97 | 23 | 102 | 12 | 18 | 96 | 12 | 24 |
| 11 | +150 | 113 | 37 | 37 | 126 | 20 | 24 | 100 | 123 | 27 | 138 | 18 | 12 | 140 | 12 | 10 |
| 12 | —150 | 100 | 43 | 50 | 139 | 16 | 11 | 100 | 129 | 21 | 140 | 11 | 10 | 132 | 14 | 18 |
| 13 | 180 | 106 | 81 | 74 | 167 | 26 | 13 | 60 | 142 | 38 | 160 | 15 | 20 | .. | .. | .. |
| 14 | Tot. Front | 98 | .. | 46 | 127 | .. | 17 | 460 | 115 | 29 | 129 | .. | 15 | 118 | .. | 20 |
| 15 | No. Expt. | 200 | | | 200 | | | 1040 | | | 160 | | | 160 | | |
| 16 | $\frac{\Sigma \text{Errors}}{\Sigma \text{St. Pos.}}$ | $\frac{630}{900}=70.0\%$ | | | $\frac{294}{900}=32.7\%$ | | | $\frac{570}{1080}=47.0\%$ | | | $\frac{290}{840}=36.0\%$ | | | $\frac{208}{720}=29.0\%$ | | |
| 17 | Eliminating 0, ±90, and 180 | $\frac{415}{720}=57.6\%$ | | | $\frac{171}{720}=23.8\%$ | | | $\frac{295}{720}=40.1\%$ | | | $\frac{270}{660}=40.9\%$ | | | $\frac{208}{720}=29.0\%$ | | |

TABLE II

| | Possible Positions: | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | Tot. No. | Av. | Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Tot. | 0 | 13 | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | 3 | 6 | 10 | 25 | 60 | 129.2 | 129.2 |
| 2 | Red. | | 9 | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | 3 | 5 | 6 | 14 | 40 | 123.2 | 123.2 |
| 3 | Tot. | +30 | .. | 1 | 4 | 2% | 6 | 2 | 5 | 2 | 3 | 7 | 8 | 6 | 17 | 8 | 5 | 9 | 7 | 4 | 4 | 100 | 109.1 | 79.1 |
| 4 | Red. | | .. | 1 | 3 | 2 | 3 | .. | 5 | .. | 2 | 4 | 6 | 3 | 9 | 6 | 4 | 7 | 2 | 2 | 1 | 60 | 105.2 | 75.2 |
| 5 | Tot. | —30 | 4 | 4 | 1 | 7% | 2 | 8 | 2 | 2 | 2 | 3 | 3 | 3 | 10 | 3 | 1 | 9 | 16 | 8 | 6 | 100 | 102.7 | 72.7 |
| 6 | Red. | | 4 | 3 | 5 | 4 | 1 | 5 | 2 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | .. | 6 | 10 | 5 | 3 | 60 | 97.5 | 67.5 |
| 7 | Tot. | +60 | 1 | .. | .. | .. | 2 | 2 | 11% | 5 | 12 | 41 | 14 | 4 | 5 | 2 | .. | 1 | .. | .. | .. | 100 | 86.9 | 26.9 |
| 8 | Red. | | 1 | .. | .. | .. | 1 | 1 | 8 | 5 | 9 | 23 | 7 | 3 | 1 | .. | .. | 1 | .. | .. | .. | 60 | 83.5 | 23.5 |
| 9 | Tot. | —60 | .. | 1 | .. | 1 | 2 | 1 | 11% | 12 | 8 | 39 | 9 | 6 | 3 | 3 | 3 | 1 | .. | .. | .. | 100 | 86.9 | 26.9 |
| 10 | Red. | | .. | .. | .. | 1 | 2 | 1 | 9 | 9 | 5 | 21 | 3 | 2 | 1 | 2 | 3 | 1 | .. | .. | .. | 60 | 84.8 | 24.8 |
| 11 | Tot. | +90 | .. | .. | .. | .. | 1 | .. | 5 | 2 | 12 | 31 | 6 | 3 | .. | .. | .. | .. | .. | .. | .. | 60 | 86.0 | 4.0 |
| 12 | Red. | | .. | .. | .. | .. | 1 | .. | 4 | 2 | 8 | 20 | 3 | 2 | .. | .. | .. | .. | .. | .. | .. | 40 | 84.5 | 5.5 |
| 13 | Tot. | —90 | .. | .. | 1 | .. | .. | 2 | 3 | 4 | 7 | 29 | 6 | 3 | 3 | 1 | .. | .. | .. | .. | 1 | 60 | 86.1 | 3.9 |
| 14 | Red. | | .. | .. | .. | .. | .. | 1 | 3 | 4 | 5 | 18 | 4 | 1 | 2 | 1 | .. | .. | .. | .. | 1 | 40 | 85.2 | 4.8 |
| 15 | Tot. | +120 | 1 | .. | .. | 4 | 1 | 1 | 1 | 2 | 9 | 33 | 22 | 14 | 8% | 2 | 1 | .. | 1 | .. | .. | 100 | 93.6 | 26.4 |
| 16 | Red. | | .. | .. | .. | 1 | 1 | .. | .. | 2 | 4 | 20 | 15 | 10 | 5 | 1 | 1 | .. | .. | .. | .. | 60 | 96.7 | 23.3 |
| 17 | Tot. | —120 | .. | .. | .. | 1 | .. | .. | .. | 5 | 7 | 41 | 22 | 15 | 5% | 1 | 1 | 1 | .. | .. | 1 | 100 | 96.8 | 23.2 |
| 18 | Red. | | .. | .. | .. | .. | .. | .. | .. | 2 | 6 | 20 | 15 | 10 | 4 | 1 | 1 | .. | .. | .. | 1 | 60 | 99.2 | 20.8 |
| 19 | Tot. | +150 | 1 | 1 | .. | 2 | 1 | 3 | .. | 2 | 3 | 3 | 6 | 8 | 18 | 11 | 5 | 19% | 14 | 2 | 1 | 100 | 122.9 | 27.1 |
| 20 | Red. | | .. | 1 | .. | 1 | .. | 2 | .. | .. | 1 | 1 | 3 | 7 | 14 | 6 | 3 | 13 | 8 | .. | .. | 60 | 125.0 | 25.0 |
| 21 | Tot. | —150 | 1 | 2 | .. | 2 | .. | 1 | .. | 1 | 1 | 4 | 7 | 2 | 14 | 17 | 15 | 15% | 13 | 5 | .. | 100 | 129.3 | 20.7 |
| 22 | Red. | | .. | 1 | .. | .. | .. | .. | .. | .. | 1 | 2 | 6 | 2 | 9 | 9 | 12 | 7 | 8 | 3 | .. | 60 | 131.0 | 19.0 |
| 23 | Tot. | 180 | 6 | 6 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 2 | 2 | 10 | 34 | 60 | 141.7 | 38.3 |
| 24 | Red. | | 2 | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | 9 | 26 | 40 | 169.5 | 10.5 |
| 25 | Tot. No. | | 27 | 17 | 12 | 19 | 15 | 20 | 38 | 37 | 64 | 231 | 103 | 64 | 84 | 48 | 31 | 60 | 59 | 39 | 72 | 1040 | Rows 1–28 show Frequency of S'd Localization at Possible Positions | |
| 26 | Grouped | | 27 | | | | | 222 | | | | 231 | | | | | 488 | | | | 72 | 1040 | | |
| 27 | Red. No. | | 16 | 10 | 8 | 9 | 9 | 10 | 31 | 25 | 42 | 130 | 63 | 41 | 52 | 27 | 24 | 39 | 33 | 25 | 46 | 640 | | |
| 28 | Grouped | | 16 | | | | | 144 | | | | 130 | | | | | 304 | | | | 46 | 640 | | |
| 29 | Unlimited | | 10 | 1 | .. | 2 | 1 | .. | 2 | 3 | 2 | 28 | 3 | 6 | 10 | 7 | 12 | 17 | 17 | 9 | 35 | 165 | Rows 29–34 show Frequency of Expectation of the Sound from Possible Positions | |
| 30 | Expectations | | 10 | | | | | 11 | | | | 28 | | | | | 81 | | | | 35 | 165 | | |
| 31 | Limited | | 65 | 16 | 19 | 42 | 22 | 18 | 29 | 14 | 22 | 138 | 17 | 20 | 47 | 18 | 21 | 31 | 39 | 21 | 56 | 655 | | |
| 32 | Expectations | | 65 | | | | | 182 | | | | 138 | | | | | 214 | | | | 56 | 655 | | |
| 33 | Total Expectations | | 75 | 17 | 19 | 44 | 23 | 18 | 31 | 17 | 24 | 166 | 20 | 26 | 57 | 25 | 33 | 48 | 56 | 30 | 91 | 820 | | |
| 34 | Grouped | | 75 | | | | | 193 | | | | 166 | | | | | 295 | | | | 91 | 820 | | |

In general these results agree, as far as agreement may be expected under our peculiar conditions, with those of previous investigators, with the one slight exception that our data seem to emphasize the tendency of sound-displacement toward the aural axis more than any other observer has so far found.

The next question, then, is to find out whether and to what extent this general tendency is modified by the determination to expect the sound from certain regions of the circumference. For this purpose we may best begin the fractionation of our data with the cases under the instruction "unlimited," because here we have a contrast between observations in which this instruction has been successfully carried out and cases in which the observers of their own accord, whether on account of misunderstanding the instruction or for other reasons, voluntarily limited their expectant attention either to definite points or to certain narrow regions of the scale. The frequency and direction of the voluntary and definitely limited expectations, regardless of individual observers, may be seen in rows 29 and 30 of Table II, while in Table III the frequency distribution of these cases is given with regard to the observers, but without reference to the direction of the voluntarily limited expectation. It will be seen from both Tables that out of the 240 possibilities, 165, or 68.75%, of the cases show the definite voluntary restriction of expectation. This tendency seems to have had no decided influence upon the accuracy of localization, as a comparison with the indefinitely restricted and the entirely unrestricted expectations indicates, according to rubrics b and c in Table I. In 71 of the 165 cases it accidentally happened that the voluntarily selected point of expectation occurred in the same quadrant as the stimulus-position. But in spite of this agreement, the accuracy of localization in these 71 cases was 3.5% less than in the remaining 94 cases. A similar difference is found between rubrics b and c, the voluntary definite restriction giving less accurate results by 3.6% than the entirely and the partly indefinite expectation. If we now compare the combined or "General Results" under "unlimited" instruction, as given in rubric a, with the total results of rubric h, the former seem to be by 3% more accurate than the total. The latter, however, is exaggerated on account of rubric f alone, which presents a special condition to be considered separately later. Without rubric f the total error would be only about 35%, which compared with the errors of rubrics a, b, and c is considerably less. In other words, the instruction "unlimited," whether faithfully carried out or not, interferes decidedly with the accuracy of localization. The introspections offer, as an explanation of this fact, unsteady attention and especially moving visual images. In addition there seems to be a tendency among some of the observers to waver between attempts not to limit expectation and temptations to visualize certain portions of the scale. On the whole the quantitative and introspective data of these experiments under "unlimited" instruction furnish an unlooked-for confirmation of the writer's previous investigation of consciousness under negative instruction.[4]

Considering next the actual direction of expectant attention, when it is thus voluntarily limited to certain points, we find, according to rows 29 and 30 in Table II, that out of 165 cases it was limited in 116 cases to the front half exclusive of $\pm 90$; if the latter be included,

[4] L. R. Geissler, Analysis of Consciousness under Negative Instruction, Am. J. Ps., April, 1912, xxiii, 183-213.

the figure rises to 144. That is to say, only in one out of eight chances do we ordinarily expect a sound to come from behind the ears. A similar tendency is evident in the experiments with limited expectation, where according to instructions all quadrants were equally often represented. Nevertheless the expectations from the front, exclusive of ± 90, are by 10% more numerous than those from the back, according to rows 31 and 32 of Table II. The reason for this preponderance of the front half lies probably in the importance of vision for our daily life,—"a sort of racial habit," as one of our observers called it in his introspections. Among the positions in the front, those of the right quadrant are preferred over those of the left in the ratio 4:3, perhaps because of the righthandedness of our observers. Taken all together, about 50% of the voluntary restrictions of expectation refer to the right front quadrant, about 37½% to the left front quadrant, and only about 12½% to the back half. To summarize, the negative instruction is in a large number of cases understood in the positive sense of "expectation *ad libitum*." With regard to the influence of expectation, this set of results has been neither definite nor extensive enough to indicate any regularities.

The experiments with positive instruction for definite restrictions of expectation, however, show undisputable evidences of the extent to which expectation may influence the accuracy of sound-localization. As should be expected, our results have not shown a single case in which a stimulus on the right or left has been localized on the opposite side. All confusions or displacements of sound occurred between the front and back halves. The most accurate localizations in this set of experiments seem to have been made when expectation was directed to the right or left half opposite to the actual stimulus-position; *cf.* rubric d in Table I; while one would have expected the best results when expectation was directed to the same half, that is, under rubrics e and g. This result is, however, somewhat distorted on account of the presence of data with the extreme stimuli 0 and 180 and the absence of data with stimulation ± 90 in rubrics f and g. Eliminating the results of rows 1 and 13 in rubrics f and g and those of rows 7 and 8 in rubrics d and e, we obtain the corrected results of row 17. But even so rubric d offers the second lowest percentage, while under rubric e the results still show a more marked effect of displacement toward the aural axis than under d or g. The only explanation that we can offer for the difference between d and e,—that is, for the fact that expectation to the opposite right or left half to some extent diminishes the earward displacement and the resulting inaccuracy of sound-localization,—consists in the assumption that such a direction of expectation does away with the kinaesthetic and visual ear-consciousness that we frequently experience in listening to faint sounds and that was explicitly mentioned in the introspections of one of our observers. This explanation is supported by the outcome of the second group of experiments, rubrics i and j, as in these cases the direction of expectation to the quarters did not favor the positions 0, 180, and especially ± 90, and therefore was rather applied to the middle of the quarters. Consequently, when the sound was given in the same quadrant to which expectation was directed, the errors were very small, averaging only 29%, while in case the stimulus was in some quadrant different from the one expected, the percentage of error was 36.0; with elimination of the one case of 180 (row 13, rubric i), it is 40.9%. This result is almost the same as that of rubric b, where there was practically no expec-

tation, and where therefore the usual forward and backward confusion observed by practically all our predecessors was influenced least, if at all, by our special instructions. Taking therefore this result of rubric b, about 40%, as our standard for comparison with the influence of definitely directed expectation, we may now proceed to show the quantitative extent of this influence, which itself is of a twofold nature. According to the direction of expectation, its influence upon the forward-backward confusion is either of a restricting or of an enhancing nature.

The former, the restricting influence, is plainly shown under rubric g, where expectation is limited to the same front or back half in which the stimulus is actually given; because in these cases the smallest errors in the displacement of sound occur, averaging a total of 32.7% for all stimuli and a reduced total of 23.8% for the intermediate stimuli exclusive of 0, ± 90, and 180. In other words, when expectation is directed to the same front or back half in which the stimulus is to be given, the usual error of sound-displacement due to forward-backward confusion is reduced more than one third. The contrary results occur under rubric f, where expectation is directed to the front or back half opposite to that in which the stimulus is actually given. Under these conditions, the forward-backward confusion is enhanced; the standard error of 40% is increased to 70% if all positions are included, and to 57.6% if the corner-positions are excluded. Considering only the latter figure, we may say that expectation increases the usual error by almost one half. Comparing the absolute differences between the standard error of displacement, 40%, and the modifications due to expectation, we find that the enhancement is practically as great in the one case as the restriction in the other case. These results, then, solve the particular problem for which our experiments had been originally planned. We may summarize our conclusion by saying that the original error of sound-displacement due to the usual forward-backward confusion is either increased or decreased by almost one half according as expectation is directed to the opposite or to the same front or back half from which the stimulus is to be given.

In addition to the results and conclusions thus far reached our data furnish a number of other results which we may now discuss. A study of the mean variations in Table I will show consistent differences with regard to certain stimulus-positions. The mean variations for 0 and 180 are greatest, then follow ± 30, and last of all ± 120 and ± 90. This result indicates clearly that the mean variations do not depend upon the inaccuracies of the individual observers, but rather upon the difficulties of localizing sound from certain directions. The question of individual differences must therefore be approached from different angles.

The attitude of the individual observers towards the various kinds of instructions, and their individual degrees of accuracy in localizing sound, are indicated in Table III. In the case of the instruction "unlimited," the last three of the eight women observers (rows 6-8) and the first nine (rows 10-18) of the twelve men are very consistent in voluntarily limiting their expectation to definite points in the circle, as the first three rubrics show; while the other observers seem to waver between this method and no (or at most an indefinite) expectation. With limited expectation the grouping is practically the same, except that one of the women (row 6) joins the wavering group and one of the men (row 19) joins the consistent group. This

difference in attitude seems to have, however, no appreciable influence upon the individual's accuracy of localization, according to the size of the average errors listed under the last four rubrics. Similarly, if we compare all observations under limited indefinite expectation with those under limited definite expectation without regard to the individuals, as is done in Table IV, rubrics k and l, we find, for the first group of experiments, at least, a very small and irregular difference in favor of definitely limited expectation. The same fact holds true with the second group of experiments, except that here the difference is somewhat larger, because most of the cases involved are from observers whose total average errors for the quadrants are considerably larger than the average for all 20 observers. It seems therefore indifferent, for the accuracy of localization, whether one expects the sound from a well-defined point or from a wider and less defined region of the periphery.

TABLE III

| Rows | | Instruction: | Unlimited or None | | | Limited Exp'n. | | Total Average Errors | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Expectation: | None | Indef. | Vol. Lim. | Indef. | Defin. | Unlim and H. | Quadrants | Combined | % |
| | | Observers: | 1st Group Expts | | | Both Groups | | Both Groups of Expts. | | | |
| 1 | Women | R.R. | 6 | 3 | 3 | 24 | 32 | 27.7 | 29.9 | 28.1 | 30.6 |
| 2 | | M.E.J. | 9 | 0 | 3 | 29 | 27 | 32.3 | 14.4 | 18.2 | 30.8 |
| 3 | | P.O. | 0 | 4 | 8 | 2 | 54 | 43.9 | 21.2 | 38.5 | 42.0 |
| 4 | | S.L. | 8 | 0 | 4 | 17 | 39 | 43.3 | 37.5 | 41.9 | 45.7 |
| 5 | | H.M. | 7 | 0 | 5 | 19 | 37 | 45.8 | 44.4 | 45.4 | 49.5 |
| 6 | | J.O. | 0 | 1 | 11 | 10 | 46 | 25.8 | 30.0 | 26.6 | 29.1 |
| 7 | | J.N. | 1 | 0 | 11 | 0 | 56 | 30.6 | 27.5 | 30.0 | 32.5 |
| 8 | | D.S. | 1 | 1 | 10 | 2 | 54 | 45.2 | 39.4 | 43.9 | 47.7 |
| 9 | Wom. Tot. | | 32 | 9 | 55 | 103 | 345 | 36.8 | 31.8 | 35.4 | 38.5 |
| 10 | Men | H.M.P. | 1 | 2 | 9 | 3 | 53 | 49.0 | 11.2 | 40.1 | 43.7 |
| 11 | | H.B. | 0 | 0 | 12 | 0 | 56 | 43.3 | 33.1 | 40.9 | 44.9 |
| 12 | | L.M. | 0 | 0 | 12 | 0 | 56 | 42.3 | 41.2 | 42.0 | 45.8 |
| 13 | | H.D.W. | 0 | 0 | 12 | 0 | 56 | 44.2 | 39.4 | 43.1 | 47.0 |
| 14 | | T.N.H. | 0 | 0 | 12 | 1 | 55 | 45.8 | 37.0 | 43.7 | 47.6 |
| 15 | | W.E.H. | 0 | 0 | 12 | 0 | 56 | 46.1 | 36.2 | 43.8 | 47.7 |
| 16 | | E.R.P. | 0 | 0 | 12 | 0 | 56 | 48.3 | 33.1 | 44.7 | 48.7 |
| 17 | | J.E.M. | 0 | 0 | 12 | 1 | 55 | 47.3 | 42.0 | 46.0 | 50.2 |
| 18 | | J.M. | 1 | 0 | 11 | 0 | 56 | 55.5 | 28.1 | 49.1 | 53.5 |
| 19 | | T.A.M. | 7 | 0 | 5 | 0 | 56 | 42.5 | 26.2 | 40.7 | 44.4 |
| 20 | | G.B. | 2 | 9 | 1 | 35 | 21 | 45.0 | 47.5 | 46.0 | 50.0 |
| 21 | | F.H. | 11 | 1 | 0 | 56 | 0 | 41.5 | 37.5 | 40.6 | 44.2 |
| 22 | Men Total | | 22 | 12 | 110 | 96 | 576 | 46.1 | 34.4 | 43.4 | 47.4 |
| 23 | Grand Tot. | | 54 | 21 | 165 | 199 | 921 | 42.4 | 33.3 | 40.2 | 43.8 |

The question of sex-difference in our experiments is complicated by the presence or absence of general scientific and specifically psychological training in our observers. Tables III and IV show a remarkable and consistent difference in accuracy of sound-localization of about 10% in favor of the psychologically untrained eight women observers. This difference cannot be explained on the basis of expectant attitude, because the five women exhibiting the indefinite wavering attitude average 39.7% as against the 45.7% of the three

TABLE IV

| Rows | Rubrics | k | | | l | | | a | | d | | e | | f | | g | | i | | j | | m | | n | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Instr. | Total Average and Errors | | | | | | Unlim. Exp'n. | | Exp. Lim. to Right or Left | | | | Exp. Lim. to Front or Back | | | | Exp. Lim. to Quadrant | | | | Total Average and Errors | | | |
| | | Indefinite Exp'n. | | | Definite Exp'n. | | | General Results | | St. opposite | | St. same | | St. opposite | | St. same | | St. in diff. | | St. in same | | 8 Women | | 12 Men | |
| | Stimulus Position | Rubrics a and d–g | | | | | | W | M | W | M | W | M | W | M | W | M | W | M | W | M | Rubrics a and d–g | | | |
| | | No. | Av. | E. | No. | Av. | E. | Av. | Av. | Av. | Av. | Av. | Av. | Av. | Av. | Av. | Av. | Av. | Av. | Av. | Av. | Av. | E. | Av. | E. |
| 1 | 0 | 7 | 124 | 124 | 53 | 143 | 143 | 122 | 144 | ... | ... | ... | ... | 109 | 163 | 79 | 131 | ... | ... | ... | ... | 103.3 | 103.3 | 146.0 | 146.0 |
| 2 | +30 | 26 | 102 | 72 | 114 | 107 | 77 | 116 | 122 | 85 | 125 | 119 | 120 | 116 | 132 | 71 | 79 | 114 | 108 | 81 | 94 | 99.0 | 69.0 | 111.4 | 81.6 |
| 3 | —30 | 23 | 119 | 89 | 117 | 99 | 69 | 100 | 127 | 91 | 112 | 69 | 125 | 95 | 132 | 50 | 90 | 111 | 136 | 75 | 92 | 85.0 | 55.0 | 116.5 | 86.5 |
| 4 | +60 | 15 | 89 | 29 | 125 | 86 | 26 | 94 | 83 | 92 | 79 | 90 | 94 | 104 | 97 | 77 | 72 | 104 | 94 | 72 | 62 | 90.6 | 30.6 | 83.7 | 23.7 |
| 5 | —60 | 20 | 70 | 10 | 120 | 89 | 29 | 109 | 80 | 75 | 97 | 77 | 91 | 96 | 92 | 79 | 74 | not given | | 66 | 76 | 83.8 | 23.8 | 85.0 | 25.0 |
| 6 | +90 | 14 | 90 | 0 | 46 | 83 | 7 | 92 | 82 | 90 | 92 | 79 | 85 | ... | ... | ... | ... | ... | ... | ... | ... | 85.5 | 4.5 | 85.3 | 4.7 |
| 7 | —90 | 5 | 100 | 10 | 55 | 75 | 15 | 97 | 86 | 90 | 87 | 82 | 93 | ... | ... | ... | ... | ... | ... | ... | ... | 90.0 | 0 | 89.0 | 1.0 |
| 8 | +120 | 24 | 95 | 25 | 116 | 96 | 24 | 95 | 89 | 95 | 95 | 99 | 93 | 80 | 84 | 105 | 103 | 106 | 101 | 104 | 101 | 97.7 | 22.3 | 95.0 | 25.0 |
| 9 | —120 | 21 | 104 | 16 | 119 | 97 | 23 | 112 | 103 | 95 | 102 | 89 | 93 | 82 | 90 | 104 | 96 | 95 | 107 | 99 | 94 | 96.7 | 23.3 | 98.1 | 21.9 |
| 10 | +150 | 19 | 126 | 24 | 121 | 131 | 19 | 139 | 129 | 157 | 123 | 129 | 103 | 127 | 103 | 127 | 125 | 142 | 135 | 140 | 141 | 135.4 | 14.6 | 122.0 | 28.0 |
| 11 | —150 | 25 | 132 | 18 | 115 | 127 | 23 | 141 | 138 | 147 | 138 | 124 | 126 | 97 | 102 | 129 | 147 | 141 | 139 | 134 | 131 | 130.6 | 19.4 | 132.4 | 17.6 |
| 12 | 180 | 12 | 103 | 17 | 48 | 151 | 29 | 132 | 164 | ... | ... | ... | ... | 94 | 114 | 177 | 161 | ... | ... | ...... | | 134.6 | 45.4 | 146.3 | 33.7 |
| 13 | | 211 Expts. | | | 1149 Expts. | | | | | | | | | | | | | | | | | 416 Expts. | | 624 Expts. | |
| 14 | Σ Errors / Σ St. Pos. | 494 / 1080 =45.7% | | | 484 / 1080 =44.8% | | | 43.3% / 45.4% | | 24.8% / 35.5% | | 32.5% / 42.0% | | 28.2% / 39.4% | | 65.0% / 73.6% | | 40.0% / 41.8% | | 24.7% / 30.2% | | 38.5% | | 46.0% | |

men showing the same attitude. But the greater frequency of this wavering among the women indicates that, as a whole, they made more frequent attempts to comply with the instruction "unlimited" than the men, of whom only two carried out this instruction in its intended meaning, while the other ten nearly always expected the sound from definite points on the circle. There was also a much greater variety as to training and age among the women than among the men, and therefore these factors cannot be used as a satisfactory basis for explaining the sex-differences. The smallest difference (about 2%) occurred when expectation was to be "unlimited" and when it was directed to quadrants different from those of the stimulus-position (rubrics a and i); next in size is rubric j (5.5%), then g (8.6%), and finally d, e, and f, which vary from 9.5 to 11.2% in their difference; but always the women's results are better than those of the men. With regard to the stimulus-positions no consistent errors between the two sexes can be found, as rubrics m and n will show. We have no suggestions to offer in explanation of these sex-differences.

Our results reveal furthermore to what extent sound-localization is more accurate in various regions of the circumference. Referring from that point of view to Table I again, especially rows 6 and 14, we see that in general (rubric h) the earward displacement from stimulus-positions in the back half (always omitting $\pm$ 90) is on an average over twice as great as that from the front half. In particular, this difference is least marked under rubrics j and f, then follow in ascending order rubrics e, g, d, a, and lastly i, where it is greatest. The localization on the right side is uniformly somewhat less accurate than on the left side, the total average errors (exclusive of positions 0 and 180) being 34.7% for right against 31.2% for left; and for the various rubrics the following corresponding pairs of figures obtain, arranged again in ascending order: smallest or no difference for f, 50.4 *vs.* 50.6%; then g, 25.1 *vs.* 23%; d, 28.5 *vs.* 26.5%; a, 34 *vs.* 28.4%; and greatest for e, 37.8 *vs.* 30.5%. This result is somewhat surprising, as practically all our observers were right-handed, a fact which would lead us to expect the opposite result. There is no difference as to sex in this respect, as the corresponding total average errors for the women are right 28.2 *vs.* 25.2% left and for the men 32.6 on the right *vs.* 30.9% on the left side. We have at present no explanation to offer for this superiority of the left over the right ear.

We are now ready to discuss the introspective reports on the mental processes of expecting and localizing sound as required from ten of our male observers. These reports are given here in full, partly for the sake of avoiding arbitrary selection, and partly in order to show the quality of introspective work which may be expected and obtained from undergraduates with average and better than average college records. The observers were told to subdivide their report into a pre-stimulation or expectation-period (A), including the conscious facts from the perception of the instruction up to the perception of the stimulus, and a localization-period (B), beginning with the sound perception. The observers either wrote out their reports themselves or dictated them to the recorder. No suggestive questions were asked by the latter; but whenever a word or phrase in the report did not seem clear to him, he demanded further details, which were to be expressed as far as possible in technical terms. The reports are numbered in accordance with the rows 10 to 21 of Table III. The small letters in parenthesis in the first part of each report refer to the cor-

responding items in the subsequent summary outline of the expectation-period, while the bracketed letters in the second part correspond to the items in a similar outline of the localization-period. The abbreviations employed are either self-evident or will be explained in the subsequent outlines.

10. A. Vis. Im. of instrument from where expected (a). Im. is projected into external space (t). Musc.-Kin. Tendency of eyes to turn (l) toward expected im. Kin. Tend. to turn head (f) toward expected noise. With "Unlimited" instruction (o) the position of instrument located by projected image (t).

B. Auditory sensation (a). If it comes from unexpected place, the original vis. im. fades and a new vis. im. (e) appears. Kin. Tend. to straighten up after sound localisation (j). If uncertain about right place, tend. to turn head (h). Sensation is pl. (q) when coming from expected direction, otherwise slightly unpl. (r). Vis. and auditory im. (e) of telephone receiver.

11. A. Conscious of kin. strains in head (f) and esp. in forehead. Kin. tend, to turn eyes (l) toward expectation-point when it was in the right or left front quadrants (n). When exp'n. was to back half (n), a kin. tendency to turn entire head (f). Whenever expected from 180°, a faint aching pressure (q) in middle of forehead and slightly toward right eye. Exp'n. of direction occurred only as kin. tend. of turning toward certain point in scale, which later in the report is translated into verbal ideas of figures [cf. B. (o)—]. All exp'n figures should be modified by the word "about" (t). In two or three cases a slight jar of apparatus gave a cue for exp'n. (s), although instructions for one or two of these were in a different direction. In the other cases the jar did not influence the direction of expectation (t).

B. After perception of sound (a), kin. tend. to nod head in direction of lines (h). Verbal ideas of reporting (o).

13. A. Vis. Im. of circle and points in circle (b). Sometimes kin. pointing in direction of instruction (k). Perhaps also eye-movements (h) in same direction. Visualised instrument at certain point (a). Several times did not expect sound according to instruction (r).

B. Sound had a space-attribute at once, and afterwards pointing, (b) and (m). Visualised a large circle on floor (g), sometimes with Vis. im. of instrument at certain point (e). Sometimes a feeling of surprise (s) slightly unpl. (r), when sound came from another direction.

14. A. Had a visual im. of the part of scale (b) from which sound was to be expected, divided into degrees. Sometimes also verbal im. of certain parts in that scale (e). Kin. strain located in neck (g) and back (j), as if leaning in required direction. When instruction was "unlimited" (o), had a vis. im. of the four points 0, ±90, and 180 (c), and whichever came first into mind was the one from which sound was usually expected.

B. The auditory perception (a) of the sound aroused a vis. im. of the instrument in the particular position (e). Pointed (m) or tended to point (i) in the direction from which the sound was heard, and then translated this into degrees of the scale, (o).

15. A. At the words "Unlimited" (o) a visual image of instrument either at 180 or at 0 (c). Just before signal "Ready" a vis. im. of instrument in front half turning from left to right (d). At the words "Ready" a vis. im. of instrument at some definite spot (a). Sometimes there is a delay in visualising the apparatus, (t).

B. Auditory sensation (a), pleasant when sound came from expected direction (q). Tendency to laugh (n) and nod head in direction from which sound came (h). Verbal ideas of translating vis. im. into terms of scale (o).

17. A. When starting in, my idea was that I could not tell much about it. Was surprised because sound seemed to come from a definite point, clear cut (t), and has been so every time except in a few cases. I had thought also that the point of expectation had nothing to do with it at all (t). At first I had trouble in locating degrees, but later a pretty good vis. im. of instrument (a), of scale with — and + posts, the zero and 180 (b) and (c). When instructed to expect sound from given half (p), I usually imaged the central point of it. When the right or left half was called for, had a peculiar feeling in one of the ears, very dim, resembling a cutaneous pressure (p), a bare consciousness of one ear (t). Sometimes had a musc. tend. in the neck (m) as if leaning the head in the direction of expectation (n). Sometimes my attention wandered to some other point of the scale (s), but almost always returned to the place told.

B. The sound (a) was heard to come from certain points (b). A kin. tend. to point to it (i), and thus the sound locates itself. The placing on the scale was mostly in verbal terms (o).

18. A. Kin. strains all over body (i). Attention directed to some point located in scale (c). Vis. im. of apparatus (a) moving toward this point (d). Vis. im. of a large circle marked in 10° points (b) and (e).

B. Auditory perception of click of instrument (a). Previous vis. im. disappear and are replaced by verbal kin. perceptions and ideas (o) of giving the position of the click. Sometimes attention fluctuated between vis. im. (u) of points 180° apart. Sometimes additional vis. im. of experimenter and recorder and of windows with strip of wall between (f).

19. A. Vis. im. of dial with pointer (a) and (b) with a special reference to red figures (c). The four points 0, ± 90, and 180 were esp. plain (c). Associated app. with a wheel with hub and four spokes at right angles (q). The vis. im. continually went back to 90 (d), but sometimes thinking I would be fooled by experimenter (r), I changed it to other points. If "Unlimited" (o), this figure seemed to revolve without stopping (d) at any place.

B. Localization was accomplished (a) either by actually pointing (m) or imaging myself pointing (k) in the direction of sound. Had a vis. im. of scale at all times (c). Imagined a straight line from sound to myself and up to myself, horizontal lines seemed about ten feet long, (g), as sound seemed to come from far distance and somewhat from below.

20. A. Tried to discover, against my will (t), what the experimenter's regular order of stimuli was; in verbal ideas (e). Expected the stim. in kin. imagery, felt that I could move or point (k) toward

the place without hearing the sound. Had a vis. im. of red letters on scale (c) and verbal idea (e) that the sound would come more frequently from their direction (t). Vis. im. of the two parts of the app. moving (d) set up by the Experimenter's steps (s) and a verbal idea that sound must come from either the one or the other point (r). My kin. position of whole body and chair never felt satisfactory in that it seemed not in the center of the circle (i) and (t). This may be one source of my errors. Had a stronger tend. to locate points in front rather than behind (t), because everything seems to be projected forward in everyday life, a sort of racial habit. Several times I thought that Experimenter would fool me and expected from another than the instructed direction (r).

B. Localization through auditory perception (b) associated with vis. memory im. of instrument and scale (c) and (e). The localization aided by expectation because I concentrated steadily in the expected region (t).

21. A. Imagined myself in center of circle divided up in degrees in vis. terms (b). When Experimenter said which half, I direct my att'n visually to that half as a whole (p), unless some noise by E caused me to pick out special place in vis. im. (s). In these cases I was inclined to lean my head in its direction (m). In second group of experiments I would have a vis. im. of map of quadrant and tend to lean my ear toward it (n) and forget about rest of circle (t). Sometimes a vis. im. moving as of app. moving (d). Twice I expected sound in opposite field from that told, because I had a verbal idea (e) that E. was trying to deceive me (r), and I reasoned out that he would put it somewhere else.

B. With aud. perc. of noise (a) I tried to select on vis. map (c) the nearest place from which I thought the sound came (d), and figure out in verbal ideas (o) the location by adding and subtracting. Sometimes I located sound first by pointing (m), which was sometimes easier, but not always. Had a tend. to bend head (h) in direction, and in some cases, esp. in group 2, I actually bent it toward sound (l). Attention was always concentrated on work (t) and affectively it was mainly indifferent (p).

The introspective items of the expectation-period may be summarized as follows in order to represent the conscious pattern of expectation. The numbers behind each item refer to the different reports in which the particular item has occurred.

### A. *Expectation-Period*

Visual Imagery
- (a) of instrument (sometimes in certain position) 10, 13, 15 17, 18;
- (b) of whole scale 13, 14, 17, 18, 19, 21;
- (c) of special parts of scale 14, 15, 17, 19, 20;
- (d) of moving instrument 15, 18, 19, 20, 21;

Verbal Imagery and Associations (e) 14, 18, 20, 21;

Kinaesthetic Sensations of Strain and Actual Movements
- (f) located in head (10), 11;
- (g) located in neck 14;
- (h) located in eyes 13;
- (i) in general or various parts of body 14, 18, 20;

Kinaesthetic Imagery and Tendencies
(k) of pointing 13, 20;
(l) of turning or moving eyes 10, (11);
(m) of moving head (11) 17, 21;
(n) of movements in special directions 10, 11, 17, 21;
Special Sensations, Imagery, and Associations
(o) for "unlimited" instruction 10, 14, 15, 19;
(p) for Halves or Quadrants 17, 21;
(q) in general 19, for special points 11;
Expectation voluntarily changed from instruction
(r) by auto-suggestion 13, 17, 19, 20, 21;
(s) by accidental noises, etc., 11, 20, 21;
Miscellaneous
(t) 10, 11, 14, 15, 17, 20, 21.

A corresponding outline may be made for

B. *Localization-Period*

Perception of Sound
(a) unqualified, by all observers
(b) with direct spatial attribute 13, 17, 20;
Visual Imagery
(c) of scale as a whole 11, 19, 20, 21;
(d) of points on scale 21;
(e) of whole apparatus in certain position 10, 13, 14, 20;
(f) of environment 18;
(g) of imaginary aids 13, 19;
Kinaesthetic Processes
(h) tendency to move or turn head 10, 11, 15, 21;
(i) tendency to point finger 14, 17;
(j) tendency to move whole body 10;
(n) tendency to laugh 15;
(k) images of pointing 19;
(l) actual movements of head 21;
(m) actual movements of fingers 13, 14, 19, 21;
Verbal Ideas of Translating localizations and of Reports
(o) 11, 14, 15, 17, 18, 21;
Affective Processes
(p) indifference 21;
(q) pleasantness 10, 15;
(r) unpleasantness 10, 13;
(s) surprise 13;
Attentive States
(t) steady concentration 20, 21;
(u) fluctuations 18.

These introspective data are not only in full accord with the numerical data from the same observers, but they also cast some light on the processes of expectation and localization of sound and on the tendency of confusing front and back. With regard to the first they show, on the one hand, that the positions 0, $\pm 90$, and 180 are especially emphasized by the visualizing expectation through greater frequency and vividness than any other positions; and, on the other hand, that the prevalence of the positions in the front half seems to be due to the predominating influence of vision upon our whole mental life With regard to the localization of sound, the reports show the impor-

tance of the kinaesthetic and cutaneous processes originating about the head, neck, and eyes. They finally suggest as an explanation of the frequent earward displacement of sound the usual bare ear-consciousness resembling a dim, cutaneous pressure. Nothing is said in these reports about a consciousness of the instruction, because, as must be remembered, the auditory perception of the instruction usually aroused at once and more or less mechanically a definite visual image, sometimes supplemented by kinaesthetic processes, of the region from which the sound was to be expected. With perhaps one exception none of the observers seems to have suspected the least influence of the direction of expectation upon his accuracy of localization, and as for the degree of accuracy itself, all observers seemed to be absolutely at sea at the end of the session. It is, finally, interesting to note that only three observers attributed more or less explicitly a spatial characteristic to sound, while the others make sound-localization an indirect function depending upon the spatial characteristics of the secondary criteria, such as the associated visual and kinaesthetic processes. But we do not wish to emphasize these and other minor details, because it was not our intention, in these brief introspective reports, to secure an analysis of the conscious mechanism of sound-localization.

We may conclude this study with the following summary of our main results and conclusions:

(1) When sound-stimuli are presented in a horizontal plane at the level of the ears, their localization shows a definite confusion of front and back with a tendency to mass the localizations around the aural axis.

(2) This tendency is strongest with sounds coming from the back.

(3) It is either enhanced or diminished to the same extent,—that is, by almost half of the original error due to front-back confusion,—by the proper direction of expectation to or away from the regions of the stimulus-positions.

(4) The tendency toward earward displacement is perhaps due to a general kinaesthetic and cutaneous "ear-consciousness."

(5) Under the negative instruction "unlimited" or "no expectation" the accuracy of sound-localization decreases by 10% of the general average error.

(6) This negative instruction is as a rule interpreted in the positive sense of "expectation *ad libitum.*"

(7) Under this instruction sounds are expected in 87½% of the cases from the front half and only in 12½% from the back. In general, sounds are also more often localized in front than in the back.

(8) This predominance of the front half over the back half in expectation and localization of sound seems to be due to the great influence of vision upon the whole of mental life.

(9) The women observers without previous psychological knowledge were about 10% more accurate in localizing sound than the men who had a uniform and moderate amount of preliminary psychological training.

(10) The left ear was found to be uniformly more accurate by about 3% than the right ear.